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Taiwan's Informatics Industry: The Role of the State in the Development of High-Tech Industry

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Introduction

In 1979, Minister K.T. Li, the man considered to be the principal architect of Taiwan's economic development, stated that "the development of the information industry is a worldwide trend, and Taiwan's economic future depends very much on our ability to catch up with this trend."[1] One year later, at a national conference on Taiwan's economy, a resolution was passed calling for promotion of two so-called "strategic industries," machinery and informatics. From that time onward, the development of the informatics industry has become a symbol for the island's economic progress. As such, it has continued to occupy a central position of the policy agenda of Taiwan's industrial and technological leaders.[2]

The decision to emphasize development of an indigenous informatics industry can be traced to two primary sources. First, even though Taiwan has enjoyed a comfortable growth rate of about 8.0 percent during the 1970s, the two oil crises (1973 and 1979) along with the two global recessions have had a severe impact on

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[1]K.T. Li, "Targets and Strategies for Developing the Information Industry in the Republic of China," December 17, 1979.

[2]For an overview of the key dimensions of the information industry in general see Michael Dertouzos and Joel Moses, eds., The Computer Age: A Twenty Year View (Cambridge: MIT Press, 1980).

the local economy. Strong pressures for major cost reductions and greater production efficiency were generated by both internal and external sources. The increased application and integration of automation and information technologies in both manaufacturing facilities and the modern office have been viewed as one effective means for responding to these pressures.

Second, by the end of the 1970s, Taiwan had reached a point where more than half of its GNP was exported. Looking into the future, however, it has become clear that the world market for some of the island's traditional products no longer looked promising, particularly in such areas as textiles and some segments of consumer electronics--where increasing protectionism in the industrialized world and growing competition made re-examination of the island's development strategy a necessity. Additionally, some of Taiwan's more immediate rivals, such as South Korea, seemed poised to embark a major move into new and more sophisticated product areas. Pressures for introducing similar shifts in the focus of Taiwan industry began to emerge. Newly emerging technologies such as informatics seem to hold great potential as a means of maintaining the island's future competitive position in the global marketplace.[3]

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[3]This theme is developed in Denis Fred Simon, Taiwan, Technology Transfer and Transnationalism: The Political Management of Dependency (Boulder: Westview Press, forthcoming).

This paper will examine the status and development of the informatics industry in Taiwan. In section one we discuss the general characteristics of Taiwan's present development strategy. We examine the broad economic and political context in which the development of informatics is taking place. In section two, we focus on the current situation in the industry with respect to overall output as well as product and market orientation. In section three we examine the taregts set by the industry and the efforts that are underway to achieve these targets. In section four, we focus on the industrial policies put forth by the government to facilitate the island's transition into higher technology and higher value-added industries such as informatics. The conclusion will then highlight some of the outstanding issues that confront both business and government as they attempt to stimulate expansion of this critical industry.

I. Taiwan's Current Development Strategy

Since the late 1970s, Taiwan has been embarked on a development program deisgned to shift the economy away from reliance on cheap, labor-intensive, low skill industries towards development of both skill-intensive and knowledge-intensive products and technologies.[4] A combination of rising domestic labor costs and structural changes in the world economy have necessitated this

[4] Japan Economic Journal, November 15, 1983, p.5.

shift.[5] In particular, Taiwan has been forced to expand exports of technology-intensive goods as the Southeast Asian nations and China have started to catch up with the island in the field of light industrial products.

Government policy has been to use a variety of instruments to lay a foundation for the development of a series of new critical industries. Depending on the circumstances, the government has been willing to act as initiator, regulator, strategic decision-maker, diffuser of technology and entrepreneur--though in the last instance it has maintained a commitment to private sector predominance. Moreover, government officials on Taiwan have recognized that "policies to promote technological advance" can be just as important as the "technology policies" themselves. Their reliance on a broad mix of policy tools underlies their belief that activities in the technological sphere have as much to do with the nature of the economic environment and the structure of incentives and rewards.

In May 1978 a new "science and technology development plan" was formulated and passed by the Executive Yuan in May 1979. The

[5]Chao Yao-tung, former Minister of Economic Affairs, attributed Taiwan's economic problems and inefficiencies in the 1970s to a)subsidization of domestic oil prices during the 1973 oil crisis, b)the slow level of indigenous technological development, c)deficiencies in modern management, d)outdated government regulations, and e)lack of proper entrepreneurial spirit. China Post, March 23, 1983, p.10.

plan laid out a development course for the island that entailed greater investment in research and development and education, industrial restructuring, and improved linkages between defense and civilian industries in high-technology fields. By 1982, a list of strategic industries was identified. These strategic industries were made eligible for a variety of tax incentives, preferential financing packages, and technological support.

The essential features of the island's new development strategy is its emphasis on these strategic industries (machinery and informatics), restraints on the expansion of energy-intensive industries, and program to modernize labor-intensive industries. This is to be accomplished through the acceleration of industrial technology development and application. The government has assumed a critical role by establishing a special commission to provide industrial guidance, expand funds for training and technological rennovation, and implement a program of industrial consolidation and corporate mergers.[6]

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[6] The reasons for the emphasis placed on industrial consolidation were: 1)Taiwan economic planners and administrators viewed the large number of small and medium size enterprises as a disadvantage as the island attempted to improve productivity and generate greater efficiency through economies of scale; and 2)after Taiwan had gone through two recessions in the 1970s, a smooth process for corporate mergers was viewed as a vital ingredient for facilitating needed economic adjustments. However, at the time, the existing tax laws actually discouraged corporate mergers. The current program, to a large extent, is designed to relax such unfavorable factors.

In essence, the government has adopted a two-pronged strategy for meeting its technological needs. One major objective has been to expand and extend the island's interdependence with key actors in high technology segements of the world economy. Through its use of various incentives designed to increase the attractiveness of the island as an investment site for advanced technology industries and as a source of high quality, sophisticated components, Taiwan is attempting to hurdle the technology gap that separates the advanced industrialized nations for most of the developing world.

The other major objective of the leadership is to strengthen the island's capacity for greater technological self-reliance. This is being accomplished by significant increases in R&D spending since the late 1970s as well as the government's willingness to absorb the financial costs of serving as the initial recipient of key priority technologies that must be purchased from abroad. As Simon has noted, "imported technologies are to be used to break down pockets of domestic technological stagnation and stimulate development of indigenous science and technology capabilities."[7]

The centerpiece of Taiwan's new development orientation is

[7]Denis Fred Simon, "Chinese-Style S&T Modernization: A Comparison of PRC and Taiwan Approaches," Studies in Comparative Communism, Volume 17, Number 2, Summer 1984, p. 91.

the Hsinchu Science-Based Industry Park. The park was created to act as a catalyst in Taiwan's efforts to move into more technologically advanced industries. It was originally conceived in 1969 and developed with the assistance of the National Science Council. The site of Hsinchu was chosen because of its proximity to two of Taiwan's leading science and engineering universities, National Chiao Tong and Tsinghua. According to K.T. Li, the park should provide the popwerhouse for Taiwan's future development in much the same way that the export processing zones created in the mid-1960s helped spark the island's greatly successful export-oriented phase of development.

Work on the park had sparked a lively debate within Taiwan's economic circles in the early 1970s as disagreement arose over the initial orientation of the park. First, there was a debate over basic versus applied research, with the former giving way to the latter. Second, at that time, many of Taiwan's economic leaders had lumped "technology intensive" and "capital intensive" industries into one category. The global energy crises, however, helped resolve the disagreement, allowing a clear distinction to be made between these two sectors. With the onset of the 1980s, Taiwan officials realized that their development objectives, including employment and income distribution concerns, could better be managed by focusing on skill-intensive industries.

By the end of 1984, 71 plants had been registered to set up operations in the park, with 56 having operations already underway. The key industries identified as investment priorities are information, communication, precision instruments and machinery, special materials, and biotechnology.[8] The interesting aspect of the park is that it is built around the presence of some of the world's leading high technology firms in microelectronics, computers, etc. On the other hand, the establishment of the park as well as the broader commitment to high technology development has stimulated the return of large numbers of ethnic Chinese scientific and technical personnel. By reversing the "brain drain" problem of the past, Taiwan officials hope the influx of returnees will serve as a pool of entrepreneurial as well as engineering talent to support high technology industry.

Taiwan's decision is to rely mainly on imported technology to spearhead activities in the park. This approach is viewed as part of a broader strategic consideration that sees the island's comparative advantage not in basic R&D, but in the ability to innovate, adapt, and improve established technologies.[9] Overall, Taiwan's bargaining position vis-a-vis technology transfer has

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[8]Of the 56 firms already in the park, 38 are involved in electronics and informatics, 9 in precision instruments, 6 in special materials, 2 in biotechnology, and one in computer services.

[9]Science Bulletin, National Science Council, Taipei, Volume 16, Number 4, April 1984.

steadily improved as a result of several factors. First, the growing presence of other high-technology firms reinforces the attractiveness of the island as a site for manufacturing of specialized components and final products. Second, there is an ample supply of qualified technical personnel and engineers, some of whom have been able to provide expert advice to the government on a host of investment proposals and/or prospective licensing agreements. And third, the overall competence of the bureaucarcy has improved due to its extensive experience in interacting with foreign firms. The value of this experience should not be underestimated since it goes a long way toward explaining why Taiwan's counterparts on the China mainland have had such difficulty in acquiring foreign technology over the last several years.[10]

Generally speaking, the government sees the park as bringing together foreign firms with local R&D organizations and the private sector. Several of the firms operating in the park are 100% locally owned. The best example of the coming together of these three actors is the highly touted United Microelectronics

[10]Taiwan's overall success regarding the acquisition of foreign technology is best exemplified by the performance of its petrochemicals industry, e.g. Formosa Plastics, as well as the achievements of such firms as Tatung and Sampo in the electronics industry. Of course, there have been exceptions due to poor planning or inadequate evaluation, resulting in very little actual technology transfer. Most observers within and outside Taiwan would agree, however, that these cases are in the minority.

Corporation (UMC). The company, which received 25% of its initial start-up capital from the Bank of Communications, a public bank for industrial development, secured its know-how as a result of a licensing agreement for integrated circuit technology that was arranged between the government-sponsored Industrial Technology Research Institute(ITRI) and RCA of the US. Today, UMC, which presently manufactures ICs for use in digital timepieces and calculators, is one of the largest IC suppliers in Southeast Asia.[11] And, it recently has made plans for a "reverse foreign investment" by signing an agreement to establish a facility in northern California's Silicon Valley.[12]

II. Status of the Information Industry in Taiwan

A. Roots of the Information Industry

In 1952, the first computer (IBM 650) was introduced in Taiwan at National Chiao Tong University. This marked the beginning of what in the 1980s would become one of the most dynamic and progressive industries in Taiwan. In its formative years, the industry amounted to no more than computer software services, ranging from equipment rentals and maintenace to basic data processing. Even during the 1970s, in spite of the fact that

[11] Free China Review, December 1982.

[12] Taiwan Industrial Panorama, Volume 12, NUmber 1, November 1, 1984.

there were some locally-made monitors being produced for export and there already was a domestic electronics parts industry in place, the existing data indicates that there was no local commercial production of computers and related products.

The big breakthrough in Taiwan's development of informatics came in 1980 when the production of minicomputers and computer terminals began. Yet, the overall output in terms of quantity and dollar value still remained negligible. A year later, however, a local television manufacturer began to mass produce terminals, which achieved an export value of US$4 million in that year. It also should be noted that, during this same time period, production and exports of other key products, such as minicomputers, disc drives, and printers began as well. Thus, while a foundation may have been in place by the mid-1970s, Taiwan did not actually move into the information industry until the 1980s--a fact that makes the present level of achievement even more remarkable.

The market orientation of the information industry is summarized in Table 3. In 1982, the industry had a total output value of US$ 67.8 million, out of which 99.6 percent derived from hardware sales. Ironically, while the production of hardware was highly export-oriented, with an export ratio of close to 94 per cent and a dollar value of US$63.6 million, the domestic market relied mainly on imports to meet demand. Imports accounted for

97% of the market in 1982. The fact that the industry was so export-oriented may seem quite surprising, but for those who have followed the development of similar industries in Taiwan in the past, the results seem quite consistent with previous experiences. In general, the level of demand from local end-users remained small at this time and did not offer much of an attraction from the perpspective of those considering future investment.[13] On the other hand, foreign firms saw Taiwan as a potential source of low cost components and specialized peripherals at an early point in time, and thus the incentives for new entrants to look outward were strong at the inception of the industry.

The growth rates of the information industry have been quite impressive. In terms of exports, the average annual growth rate between 1981-1984 was 278%. Obviously, part of the reason for the tremendous rate of increase is due to the small base from which it started. Yet, projections for 1985 are that total exports will reach US$810 million, a considerable jump from the 1984 total of US$326.8 million. In 1984, exports of information-related equipment and components constituted 26.9% of total electronics exports. In this same year, electronics, for the first time, replaced textiles as the island's leading export industry. If

[13]It also must be recognized that, in many cases, local producers could not produce the type of sophisticated equipment that was desired.

present trends continue as projected, informatics will occupy an increasingly large portion of the electronics industry as well as Taiwan's overall export mix.

B. The Commodity Structure of the Information Industry.

The trade statistics shown in Table 2 present a clear picture of the commodity structure of the informatics industry on Taiwan. First, terminals have dominated the industry's exports, accounting for two-thirds of the export market until 1984. In 1985, however, it is projected that the share of overall informatics exports accounted for by terminals will drop to around 40 per cent. The second major export item is the personal computer, whose share of informatics exports in 1985 is expected to be 35-40%. Two additional items, disk drives and printers, are also expected to be significant export earners, with projected export values of US$100 million and US$80 million respectively.

While the relationship of the above products to the information industry is quite clear, in some other areas, the distinction is much more cloudy. For example, in the case of monitors and computer parts, it is difficult to assess the dollar amounts of the output that are directly associated with use in the information industry. Before 1982, these two items, which originally were developed in the 1970s, accounted for a much

larger quantity and value of exports than the four above products.(See Table 2). In 1984, the total export value of monitors was US$318 million, which was only slightly less than the total of export value of terminals, personal computers, disk drives and printers, combined--which amounted to US$326.8 million.

For 1985, the projected export target for monitors is US$430 million. If one broadens the definition of the information industry to include a larger range of related electronics products and components, then the total export value of informatics equalled US$1,005 million in 1984 and will likely surpass US$1.7 billion in 1985. By the first quarter of 1985, informatics exports, broadly defined, totalled US$322 million, an increase of 126% over last year, suggesting that the target is well within reach.

The dominant position of monitors in the overall export mix of informatics products, especially in the 1980s, should not be a major surprise to those who have followed Taiwan's industrial and technological development over the last two decades. By the mid-1970s, Taiwan already had become a major producer of televsion sets. In 1979, exports of black & white TVs totalled 4.8 million units, while exports of color TVs reached 1.3 million sets. By 1984, total exports of color telvisions was valued at US$400 million. In many respects, the monitor industry is, in fact, a

part of the television industry. In a large number of cases, the monitors that are making inroads in foreign markets are being manufactured by current or former producers of television sets. As the market for black & white televisons began to shrink at home and abroad, producers looked to move quickly into feasible substitutes, of which the monitor was a readily available alternative.[14]

C. Product and Technology Development

Given the short history of the informatics industry in Taiwan, the general product and technology base has just begun to take shape. In addition, the nature of industrial organization has been mixed, with a variety of different roles being played by government, the private sector, and foreign-based actors. The experience of local firms who have entered into the information industry has reflected five different modes of start-up and organization.

The first model is characterized by companies founded by people who have had first hand experience in dealing with infor-

[14]Taiwan's ability to expand exports of monitors can be attributed to several factors: a)increases in local content from 40-60%; b)sharp competition between Japan and the US that has driven American firms to switch their CRT production sites to Taiwan; and c)growing technological capabilities. In addition, demand for CRT terminals is expected to grow over the next several years.

mation technologies themselves and have taken the growing demand for informatics products as an opportunity for starting their own businesses. For example, Multitech, a local computer that is based in the Hsinchu Science and Industry Park, was founded by a few university professors in 1976. The company's first product was not a computer, but rather was automation testing instruments for industrial use. In 1976, its first prototype computer was assembled; its main use was for educational purposes. Later on, after developing the sequential control language, the firm began to engage in R&D related to computers and turned out its first self-designed mini-computer for industrial use a few years later. In another case, when the government shut down all television game playhouses in 1981, some television game manufacturers moved into assembling personal computers. This type of company is general small in size and depends to a high degree on the technical expertise of a few select individuals.

Another group of companies became involved in the industry by marketing products for large foreign firms. After the company has been able to master some technical know-how, it has moved into product manufacturing. In some cases, a number of these firms were invited by their foreign partners to engage in such production. In most instances, these firms have maintained their links with foreign companies as a means to secure additional access to technology and market information.

A third group of companies was organized by large multi-national firms through foreign direct investment. Qume, for example, has terminated its production of disk drives in the US and moved its entire manufacturing line to Taiwan. Wang Laboratories also has a sizable venture in Taiwan both in manufacturing mini-computers and in local-based R&D. Generally, these foreign firms have preferred to retain 100 per cent ownership in their investments. They see their business acitivities in Taiwan as a means to support their overall marketing and development activities for responding to changing demands and new technological opportunities.

A fourth category of companies got their start-up in response to initaives on the part of the government. In an effort to encourage entry into particular product segments and technology areas, the government has been willing to absorb part of the start-up costs in terms of capital investment and, on occasion, by providing assistance in securing foreign technology and then diffusing it to a local firms. In some cases, the government has been known to contribute as much as 50% of the paid-in capital. And, it has been satisfied with allowing these firms to maintain their status of privately-owned ventures. Such instances where these types of public-private interface take place usually involve large-scale efforts focused on the development of new, special-

ized technologies.

The last category of firms has been organized directly by large domestic firms who are anxious to expand their own product lines. Most of the technology has been acquired through licensing or other cooperation agremeents with foreign firms. In some cases, these firms also have engaged in outward foreign direct investment in their dominant product areas--which may or may not have been outside of informatics. For example, a few years ago, a local cable and wire producer, the largest one in Taiwan, decided to set up an R&D laboratory in Silicon Valley in California. In early 1985, this same firm also established an integrated circuit plant, of which 15% of the capital was provided by the subsidiary in the form of specialized technical know-how.

Each of these different categories, however, is not mutually exclusive. In 1984, three new "local" firms began operations in the Hsinchu Park. One of the firms, the New Development Corporation (NDC), which is a joint venture with the China Development Corporation and ITRI, signed a five year contract with IBM to design and develop products for that company. IBM will send out technical personnel to NDC to assist with product research; it also agrees to purchase all the products NDC turns out in both the microcomputer and software areas. By engaging in such a venture, NDC hopes to acquire new software development methodology while

obtaining the marketing channels of a large, highly successful multinational firm. In return, IBM hopes to be able to develop hardware and software packages of satisfactory quality at fraction of the development cost in the US.

The level of technological advance in the informatics industry has been appreciable, particularly in view of the fact that just a few years ago, this industry did not even exist on the island. Several major technological breakthroughs were made during 1984. For example, a 3.5 micrometer 64 K CMOS D-RAM was developed in November 1984. Less than 6 months later, the technology for 1.5 micrometer 256K CMOS D-RAM was mastered. Only two other firms in the world, Hitachi (Japan) and Intel(US) have been able to develop this technology. The next step is aimed at 1.0 micrometer 1024K chips. Also in 1984, the first 16-bit personal computer was marketed. Recently, Phillips Taiwan proposed production of 0.29 m.m. high analytical color picture tubes in the future. The significance of this announcement, however, was somewhat tempered by the fact that a locally-based firm had already been working on a similar product for some time.

Along with hardware development, Taiwan firms also have played close attention to software development. They recognize that without development of standardized software packages foreign firms will continue to have advantages in the local market and

Taiwan-made machines will not be able to gain widespread acceptance in foreign markets. In this regard, development of a new software package called "the big five," including a Chinese language word processing system, an electronic calculation sheet, a file management system, a graphics system, and a communication system, has been given support by the government and is scheduled to be introduced into the local market by June 1985. The ability to develop Chinese language software is a main attraction for the growing foreign investments by foreign firms. Some of the large multinationals such as HP and IBM wish to further strengthen their competitive position in Asia by gaining access to such specialized software packages.[15]

III. Industry Targets and Efforts

In order to promote the development of the informatics industry in Taiwan, the government has set up a series of production and marketing targets over a ten-year period. More specifically, the Council for Economic Planning and Development under the Executive Yuan has worked with several other organizations to develop a ten-year plan for the industry. The current plan calls for the accomplishment of five major tasks: 1)to increase the use of computers at all levels of government organizations; 2)to

[15] Science Bulletin, National Science Council, Taipei, Volume 16, Number 6, June 1984.

develop and manufacture mini-computer systems and selected peripherals; 3)to establish software engineering capabilities; 4)to develop an expanded base of trained personnel; and 5)to build an electronics/information science and technology exhibition center to serve as a central headquarters for the informatics and electronics industries.[16] The government hopes to achieve these goals through several primary means:

a)popularization of the benefits of computers and their applications in business and government;

b)identification of government-supported domestic markets for informatics products to attract domestic and foreign investments as well as to accelerate the accumulation of needed technical experience and managerial skills;

c)encourage more participation of foreign firms in the overall development of the informatics industry; and

d)improve organizational coordination and planning.

By 1989, total output in the information industry is projected to reach US$4.6 billion, of which US$3.9 billion will be from hardware and US$0.7 million will be from software. Total exports of hardware and software are slated to be US$2,820 million and US$350 million respectively. Given present rates of growth in information industry product output in other countries, Taiwan-made products should occupy about 2.0% of the world market. To achieve these goals, the industry will have to attain an average

[16] The Current Development of the Software Industry in Taiwan, ROC, Institute for Information Industry, Taipei, November 1982.

annual growth rate between 1982-1989 of 78%. (See Table 3)

These targets, however, will be difficult to achieve. There are both technological constraints and market barriers that will limit Taiwan's ability to obtain 2.0% of the world market. Nonetheless, one cannot discount the industry's potential. Output of informatics products on the hardware side has been increasing at a tremendous rate: 241% in 1983, 382% in 1984, and 148% in 1985. Thus, it is not inconceivable that the above projections could actually be achieved. The possibilities are also enhanced by the fact that Taiwan producers are often able to overcome their own limits in assessing exports markets by tying themselves closely to the needs of foreign firms from the US and Japan.[17]

In February 1982, a special government-sponsored task force under the Executive Yuan was set up to promote the growth of the informatics industry. Under the jurisdiction of the special task force are three government organizations at the ministry level and two non-profit ones. (See Chart 1) It is the function of the task force to ensure that activities among these five units are well-coordinated and focused on the priority areas selected for

[17]One of the critical weaknesses of the Taiwan economy has been its dependence on foreign firms, especially trading companies from Japan, for discovering emerging market opportunities. Government efforts have been underway to establish several large trading firms, similar in structure and orientation to those from Japan, in order to gain more autonomy in dealing with the marketing of locally-produced items.

the industry in the ten-year plan. In July of that same year, an implementation plan was announced, laying out 22 tasks in seven categories: manpower development, technology development, market development, government aasistance, promotion of the public interest, encouraging foreign investments, and modification of government procurement practices.

In terms of specific responsibilities, the two non-profit organizations play a critical role in terms of research and development. The first organization, the Institute for the Information Industry(III), concentrates on software development. For example, the "big-five" project mentioned earlier was sponsored by the III. Founded in July 1979, the III is jointly supported by government, academic institutions, and private organizations. (There are 43 members on the Board of Trustees, 6 from government, 7 from academia, and 31 from the private sector.) Its main mission is software development, including providing advice and guidance to government and private organizations.

The other organization is the Industrial Technology and Research Institute(ITRI). As noted, ITRI is the largest R&D organization on the island. Within ITRI are several specialized institutes; the key one in the information industry is the Electronics Research and Service Organization(ERSO). ERSO operates its own integrated circuit facility and a related

subsidiary in the Hsinchu Science-Based Industry Park. Several of the critical innovations that have spearheaded the emergence of Taiwan's integrated circuit industry have come from within the ERSO laboratory.

As a knowledge-intensive industry, research and development play an important role vis-a-vis the development of new technology and products.[18] Total R&D expenditures for the information industry in 1979 were US$4.1 million, or 3.1% of Taiwan's total R&D expenditures during that year. By 1982, that amount increased to US$37.4 million, or 11.0% of the island's overall R&D spending (excluding defense). During 1982, the electronics industry spent approxmiately 1.10 % of the industry's sales on R&D. Based on a recent sample of 26 firms in the informatics industry, however, spending on R&D averaged 3.3% of sales, reflecting the high-degree of R&D intensity within that rapidly growing sector.[19] At the same time, Korean electronics firms spent 2.44% of sales on R&D in 1982, American firms spent 7.6%(1980), and Japanese firms spent 4.06%(1981).[20]

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[18]"The Republic of China's 4 Year Plan: R&D in Science and Technology," Industry of Free China, Volume LIX, Number 5, May 1983, pp.21-36.

[19]S.C. Ke, Technology and Administrative Control: A Case Study of the Minicomputer Industry (Draft).

[20]For Taiwan, the next three major areas of high R&D expenditure (1982) are automation--US$26.3 million, special materials--US$21.1 million, and energy--US$14.2 million.

The pattern of growth in R&D spending in the information industry is consistent with the general increases in R&D expenditures over the last several years. In 1979, total R&D spending in Taiwan was US$133 million, or 0.42% of GNP. By 1982, this amount increased to US$321 million, or 0.7% of GNP. The R&D/GNP ratio was aimed at 1.0% in 1984, and is expected to climb to 1.2% in 1985 and 2.0% in 1989. Given this trend, it is probable that projections for R&D spending in the informatics industry will be met and will that the informatics industry will continue to be the island's leading R&D industrial and technological target.

As a result of its designation as a "strategic industry," companies active in the informatics field are eligible for a special low-interest loans. If the firm's proposal includes one of the 150 selected priority projects chosen by the information industry task force, it can obtain funds at 2% below the regular long-term loan rates. So far, a total of US$3.75 million has been made available to domestic firms to support product development. Among the applicants, the electronics parts producers took the lion's share--25.73% of the total funds. Informatics firms, including software producers, took another 10.5% from the pool. It is the government's intention to increase the size of this pool in order to encourage substantial increases in R&D and investment in both product and process technology.

IV Industrial Policies in the Information Industry

Along with the previously mentioned special organizations to promote the information industry and the availability of low-interest loans, there have been several other incentive packages that have been introduced to stimulate technological advance and new product development.

1. Tax Incentives

The latest revision of the Investment Encouragement Law, which was promulgated in December 1984, provides a very generous tax deduction for R&D spending. Under the prevailing statute, R&D expenses are totally deductible for the year in which they occurred, accelerated depreication can be applied to instruments and equipment purchased for R&D, and machinery and equipment imported for R&D are exempt from import duties. Also, any firm may request a deduction in corporate income tax equivalent to 20% of the company's additional R&D spending above the previous 5-year peak--but no more than 50% of the total corporate income tax liability. Another tax incentive that is soon to be introduced is that no foreign firm will have to pay income tax on royalties paid by companies in selected industries, one of which is informatics.

2. Direct Foreign Investment(DFI)

Direct foreign investment has made a significant contribution to Taiwan's export growth as well as the transfer of technology.[21] By the end of 1984, almost every major multinational firm involved in the electronics industry had a venture in Taiwan. US firms have been the dominant participants with some recent increase in activities occuring among companies from West Europe and Japan. Most of these firms have come to Taiwan in response to the quality of the skilled labor force as well as the cost of skilled labor. This stands in sharp contrast to the past when the cost and availability of unskilled labor for simple assembly operations was the principal attraction of Taiwan.

Within the context of the move towards more technology-intensive industries, Taiwan's policies towards foreign investment have undergone significant changes in emphasis since the mid-1970s. In general, while becoming more selective, the government has also attempted to remove much of the red-tape that was a frequent source of complaints among foreign businesses in the past. Taiwan officials have let it be known that even in sites such as the export processing zones, they no longer encourage labor-intensive investment projects, preferring instead investment proposals that bring new technology or products to the island. Improved capa-

[21] Gustav Ranis Chi Schive, "Foreign Investment and Taiwan's Economic Development," in Walter Galenson, ed., Trade and Investment in Asian Countries (Madison: University of Wisconsin Press, forthcoming).

bilities in screening and evaluating foreign investment projects has gone a long way toward helping to ensure a better match between Taiwan's development needs and the objectives of the foreign firms.

In an effort to attract more foreign firms to come into Taiwan, a variety of policy changes have been introduced in the investment regulations governing foreign investment. First, the previous requirements regarding export commitments are gradually being dropped, with the expectation that they will be largely eliminated over the next few years. Second, foreign firms, along with the domestic firms, will soon be eligible for the special low-interest loans mentioned previously in the paper. Given the fact that the interest rate on "preferential" long-term financing in Taiwan has generally been lower than that in most of the OECD countries, except for Japan and West Germany, the availability of these monies might prove to be a major investment incentive.

3. Other Related Policies

The Hsinchu Science-Based Industry Park offers an ideal set of incentives for potential investors in the informatics industry. A five year tax holiday is offered--but under the present circumstances, the investor can choose to begin the holiday period at any time during the investment's first nine years of operation. Moreover, the park acts as a "technological hothouse,"

where high-tech firms can be situated in one strategic location. Thus, from the perspective of those in the informatics industry, the growth in the park and its facilities is viewed as a continued benefit, especially in terms of attracting competent personnel and receiving government support.

Relatedly, a venture capital market was set up a year ago in order to help capitalize entrepreneurs looking to start operations in high-technology fields. Three firms have been established so far. In addition, the domestic stock market was opened up to foreigners in 1984, thereby further strengtheing the opportunities for progressive ventures to get underway. The government has also taken strong steps to respond to the problems of industrial counterfeiting, a problem which has discouraged some firms from bringing advanced portions of their production and R&D activities to the island.[22] Severe penalities have been introduced for those who violate the proprietary rights of other firms. An island-wide inspection agency for the information industry has been established in order to better ensure the sanctity of technology and know-how.

The government has also retreated from its generally protective stance regarding the development of new, emerging indus-

[22] IBM is one firm that has experienced severe problems with respect to alleged counterfeiting of its products and technology by Taiwan firms. Asian Wall Street Journal Weekly, October 22, 1984.

tries. As a result of the encouragement of several progressive government officials, a decision was made over the last several years to relax some of the previous restrictions and heavy duties on imports. Government officials hope that the growing presence of foreign products will help generate sufficient competition for overly complace nt local firms, thus stimulating them to pay more attention to R&D, product design, marketing, cost, etc.

V. Prospects and Conclusions

Recognizing that the informatics industry represents the technological wave of the future, Taiwan authorities have made a concerted effort to establish both a technological and manufacturing base for the industry on the island. In order to accomplish this goal, they have designated the information industry as one of the island's strategic sectors and have provided a host of incentives to present and potential entrants. In addition, through the establishment of organizations such as the III, the government has created an institutional framework for better coordinating the activities of both public and private actors. These actions all serve to reinforce the critical role played by the state in developing this high-priority industry.

At the same time, it must also be recognized that the government on Taiwan has not chosen to establish a public enter-

prise in this field, though the public sector plays a dominant role in the energy and several other heavy industries, e.g. steel, shipbuilding, etc. Instead, its on-going strategy has been to absorb some of the start-up costs for the industry as a whole, thereby reducing, and in some cases alleviating, the investment risks for the private sector. The government has provided substantial amounts of capital to facilitate the emergence of new enterprises in a number of key product lines, but it has always remained careful to leave the management to the private sector. Past experience has taught Taiwan officials that in order to develop a globally competitive industry, the quality and standards of the products as well as their overall cost structure must be judged first and foremost by the requirements of the market.

The ability of the industry to produce computer-related equipment has improved over the last few years, largely in the medium-technology end of the spectrum. Moreover, Taiwan has moved into the development of some frontier technologies and products. Yet, mass production of these items has been carefully considered before moving forward. Instead of seeking to compete head on with firms from the industrialized nations, Taiwan has pursued a market niche strategy, seeking out specialized segments of the informatics market where it can develop a secure, but competitive advantage. This has meant that producers have concentrated on specialized peripherals and related items as well as serving as

OEMs for some of the leading multinationals from Japan, the US, and Western Europe. In this regard, the state also has played a critical role in structuring the relationships between the local economy and the large foreign firms, minimizing potential "damage" to local industry and facilitating the transfer and diffusion of technology.

The current success of the industry can be attributed, in large part, to the strong televison and electronics parts industries that were created during the late 1960s and 1970s. Production of monitors, terminals, and components such as semiconductors share many of the same technological skills and manufacturing requirements that had been mastered earlier. In addition, once established as reliable producers and plugged into active market channels, some of firms found it easy to make the transition into these other product lines, especially since they were supported in their efforts by foreign firms.

Also, this paper has focused on the civilian dimensions of the information industry, ignoring the important role played by the military in providing funds for R&D and stimulating technological advance. In Taiwan, the military has become a major user of advanced informatics products and components. And, in the future, demands for such advanced products will likely increase, especially since there is a strong effort underway to promote

stronger links between the civilian and defense industry. Software development appears to be the primary area where activity will increase at the fatest rate. As such, in addition to responding to foreign market demands and internal demands of a civilian nature, we may also see defense needs playing an even larger role in pushing out the existing technological capabilities of the industry.

Of course, the development of the informatics industry has not proceeded without problems. In spite of the rapid growth of the industry, in some respects, the strong technological and economic base that is needed to support the industry has not evolved to the extent desired by top government leaders. The implementation of the Statute for the Encouragement of Investment has not always been well-coordinated with the development of the informatics industry, hindering, at times, broad scale computer development and applications. Also, private sector investments in R&D continue to lag--a pattern that has been typical of many Taiwan companies in other industries in the past. There also have been difficulties interpreting the various aspects of the tax incentives for R&D-related activities, especially since its is hard to define R&D and to make accurate determinations about the end-use of imported equipment. And, on several occasions, financial assistance for various projects has been slow to materialize because in R&D-intensive sectors, calculating precise

returns on investment is frequently problematic.

This litany of problems might lead one to suggest that the difficulties have out-weighed the level of progress, but this is not the case. The movement into high-tech industries such as informatics represents a great challenge to both the government and private business due to the complexity of the problems, the broad scope of the sub-sectors and technologies involved, and the need for a high degree of coordination, cooperation, and competition. And, in spite of the problems with "pirating," the current shift towards skill-intensive and knowledge-intensive industries has continued to receive strong support from the foreign business community. Informatics has become Taiwan's industry of the future--as Minister K.T. Li suggested it should. The challenges ahead will be to ensure more consistent implementation of government policies and to maintain the momentum that has appeared since 1980. These will not be easy tasks, particularly as the informatics industry becomes more competitive on a global basis. Nonetheless, the prospects appear bright as Taiwan officials have tried to give each of the key actors--governnment organizations, private sector companies, and foreign firms--a vested interest in the success of the effort.

Chart 1

Organizations Promoting the Information Industry

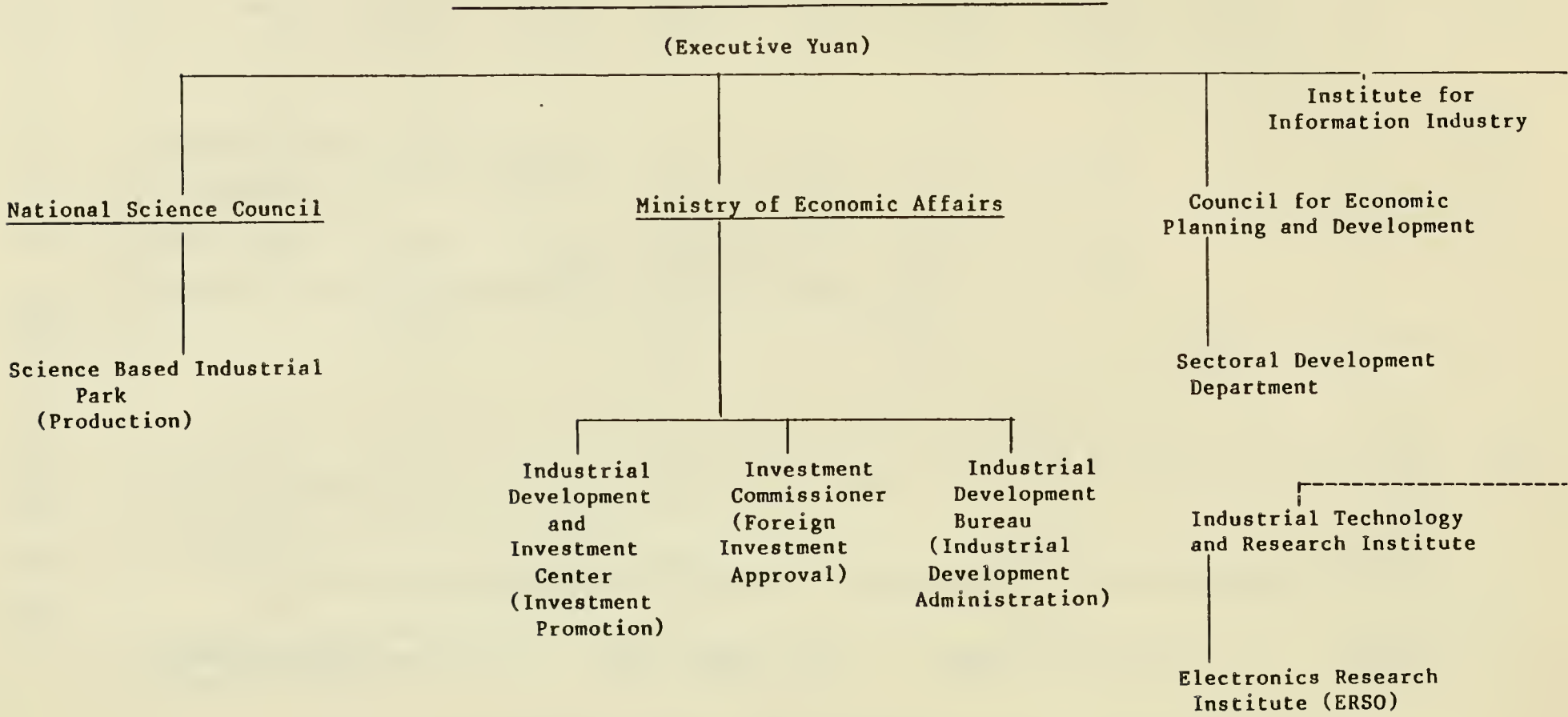

Table 1

Domestic Markets Sales, Production, and Exports of the Informatics Industry

Unit: $ million (%)

	Domestic Market [1]	Local Supply (% of)	Domestic Production [2]	Exports [2]
1972	3.4	0	0	0
1979	19.7	0.0	0.1	0.1
1980	54.4	0.6	5.4	5.0
1981	65.8	0.6	14.3	13.9
1982	115.5	3	67.5	63.6

Source: Promotion of the Information Industry, the First Stage Report (Institute for the Information Industry, 1984).

Note: [1] Including software.

[2] Excluding parts, including monitors.

Table 2

Exports and Imports of the Informatics Hardware 1980 - 85

Unit: $ million (1,000 units)

	p.c.		Terminals		Disk Drives		Printers		Total	Monitors	Parts
Year	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Exports	Exports
1980	N.A	N.A	N.A	8.2	N.A	N.A	N.A	N.A	N.A		
1981	0.4	8.9	4.0	8.2	0.0	0.8	0.1	8.1	4.5	8.6	91.8
1982	2.0 (1.6)	13.1 (0.5)	12.8	11.7 (122.0)	0.4 (5.4)	2.7 (0.3)	4.6 235.7)	11.2 (6.6)	19.8	33.6	95.6
1983[1]	6.4 (37.2)	6.8 (5.4)	43.3 (283.9)	10.8 (2.9)	6.0 (62.2)	11.8 (94.5)	11.9 (144.7)	8.7 (17.6)	67.6	36.1[2]	71.3
1984[3]	15.0		206.0		83.0		22.8		326.8	318.0	
1985	300.0		330.0		100.0		80.0		810.0	430.0	

Source: 1. Promotion of Information Industry, the First Stage Report (Institute for the Information Industry, 1984).

2. United Daily News, April 19, 1985.

3. S.C. Ke, Technology and Administrative Control: A Case Study of Mini-Computer Industry (Draft)

Note: 1 For the first nine-months only
2 For the first six-months only
3 Estimated figures

Table 3

1989 Targets of the Informatics Industry
Unit: $ mil

	Domestic Production							Domestic Market (%)			
	Hardware			Software			Total	Hardware		Software	
Year	Exports	Dom. Mkt.	Total	Exports	Dom. Mkt.	Total	Total	Imports	Total	Imports	Total
1982	63.6 (94.0)	3.9 (6.0)	67.5	0.3	0.0	0.3	67.8	112.0 (97.0)	115.5	7.0 (100.0)	7.0
1989	2,820.0 (72.0)	1,080.0 (28.0)	3,900.0	350.0 (50.0)	350.0	700.0	4,600.0	720.0 (40.0)	1,800.0	150.0 (30.0)	500.0
Annual Growth Rates (%)											
	72	123	78	N.A	55	N.A		30	48		84

Sources: Promotion of the Information Industry, the First Stage Report (III, 1984).

Table 4

R&D of the Information Industry
$ million (%)

	1979	1982
Government	3.4 (83.9)	N.A
Private	0.6 (16.1)	N.A
Total	4.1 (100.0)	37.4
% of Country Total	3.1%	11.0%

Source: 1. Development Planning of the Information Industry (CEPD, 1982).

2. Survey of Science and Technology Republic of China, 1982 (National Science Council, 1984).

Table 5

R&D of Republic of China
Unit: %

	1978	1979	1980	1981	1982	1984[1]	1985[1]	1989[1]
% of GNP	0.30	0.42	0.55	0.76	0.70	1.00	1.20	2.00
% from Private Sector	27.3	35.4	52.4	55.6	54.3	N.A	N.A	N.A

Source: 1. Survey of Science and Technology, Republic of China, 1982 (National Science Council, 1984)

2. Council for Economic Planning and Development

Note: [1] Target figures

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